June 1, 2021

BY ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: Viasat, Inc., *Ex Parte* Presentation
Long-Form Application of Starlink Services, LLC, Auction 904 File Number 0009395128, *et al.*;
The Rural Digital Opportunity Fund (Auction 904), AU Docket No. 20-34;
Rural Digital Opportunity Fund, WC Docket No. 19-126;
Petition of Starlink Services, LLC for Designation as an Eligible Telecommunications Carrier, WC Docket No. 09-197;
Expanding Flexible Use of the 12.2-12.7 GHz Band, WT Docket No. 20-443

Dear Ms. Dortch:

In its letter of April 5, 2021, Viasat provided extensive technical analysis demonstrating that even if SpaceX deploys a full, 4,408-satellite Starlink system, Starlink falls short in satisfying SpaceX's RDOF commitments in a number of material respects.[1] SpaceX has provided *no* direct response to that technical analysis. Instead, SpaceX has largely ignored Viasat's filing.

Indeed, SpaceX has publicly acknowledged Viasat's April 5 submission only once, in a single paragraph included in a filing responding to *another* party that opposed the Starlink ETC designation petition. In that paragraph, SpaceX suggests in summary fashion that technological improvements of an undisclosed and indeterminate nature would somehow solve all of Starlink's capacity problems.

Viasat files this further analysis to underscore three critical points:

- SpaceX's suggestion that it can overcome Starlink's capacity limitations through unproven "technological advances" of an unspecified nature is fundamentally inconsistent with the Commission's RDOF framework;

1 *See* Letter from Viasat to FCC, Auction 904 File Number 0009149922 *et al.*, AU Docket No. 20-23 *et al*. (Apr. 5, 2021) ("Viasat Letter").

- Viasat's technical analysis relied on assumptions that were unduly favorable to SpaceX, and thus understate the extent of Starlink's capacity issues; and

- In any event, SpaceX is constrained by the laws of physics in its ability to realize capacity improvements in the Starlink network.

These matters *must* be fully addressed ***before*** SpaceX is awarded any RDOF funding. Failure to do so would create a significant risk of a SpaceX default, with significant adverse consequences for unserved locations, the integrity of Auction 904, and the integrity of future auctions that could occur before an ultimate SpaceX default on its Auction 904 obligations becomes evident.

I. Background

In its April 5 letter, Viasat provided extensive technical analysis, using three different methodological approaches, to demonstrate that the Starlink system does not have the ability to serve the RDOF locations that SpaceX was provisionally awarded in Auction 904. Significant shortfalls in Starlink capacity exist because of a fundamental disconnect between (i) the maximum theoretical geographic concentration of the bandwidth of each Starlink satellite given SpaceX's commitment to maintain Nco=1 and (ii) and the geographic density of the specific RDOF-locations that SpaceX bid and provisionally won:

- ***First***, Viasat demonstrated that there are multiple geographic areas throughout the country where the density of the RDOF locations provisionally awarded to SpaceX exceeds available Starlink capacity given SpaceX's repeated commitments to operate its NGSO system license consistent with the "Nco=1" limitation on spectrum reuse. These areas contain about 13% of SpaceX's provisionally awarded locations.

- ***Second***, Viasat demonstrated that in a number of larger areas the complete 4,408-satellite Starlink system would not have a sufficient number of satellites available at times to serve the provisionally awarded locations in those areas at the requisite "Above Baseline" performance requirements (*e.g.,* 100 Mbit/s downstream speed with 80/80 availability, 2 TB per month per location, and 100 msec latency).

- ***Third***, Viasat demonstrated that the complete 4,408-satellite Starlink system would be able to provide Above Baseline service to only a portion of all of the RDOF locations provisionally awarded to SpaceX.

It has now been almost two months since Viasat submitted its technical analysis, and SpaceX has provided no direct response. The closest SpaceX has come to addressing Viasat's analysis is the inclusion of a single paragraph in the middle of comments responding to *another* party (the "Ensuring RDOF Integrity Coalition") that opposed SpaceX's ETC designation petition.[2] That paragraph makes only passing reference to Viasat's showing and essentially

[2] *See* Starlink Services, Inc., Reply to Comments on ETC Designation Petition, WC Docket No. 09-197, at 6 (Apr. 22, 2021) (footnote omitted). Viasat was not copied on that response.

dismisses it out-of-hand, without identifying any specific technical deficiencies either with the assumptions or the methodology. More specifically, SpaceX asserts that:

> The authors of the . . . Viasat-funded analysis make numerous factual errors and rely on incorrect assumptions to reach their pre-determined conclusions. For instance, they assume technology is frozen in time and fail to account for even basic future development. While that assumption may hold true for the technologies used by the reports' funders, it does not reflect the rapid deployment of the Starlink network. They [(*i.e.,* Viasat)] fail to account for newer generations of customer premises equipment, software, or satellites. These improvements are not theoretical or in the far-off future—they have either already been introduced or are in the process of introduction. Indeed, Starlink is specifically designed to take advantage of technological advances to serve increasing consumer demand. By replacing our satellite fleet at a regular cadence, Starlink is able to rapidly introduce new technology into our constellation, bringing ever-increasing amounts of network bandwidth to our customers.

SpaceX's position essentially reduces to: (i) a vague and entirely unsubstantiated claim that Viasat's analysis is premised on "factual errors" and "incorrect assumptions" of an unspecified nature; and (ii) broad assertions that technological improvements of an unspecified and unproven nature will overcome the significant constraints identified by Viasat. This position is entirely unsupported, utterly inconsistent with the legal standards that RDOF applicants are required to satisfy within the Commission's RDOF framework, and contrary to technical limitations on SpaceX's ability to expand its available capacity.

II. <u>SpaceX's Suggestion that It Can Overcome Starlink's Capacity Limitations through "Technological Advances" Is Inconsistent with the Commission's Framework for Evaluating RDOF Long-Form Applications</u>

Tellingly, SpaceX's limited discussion of Viasat's April 5 technical analysis does *not* dispute the key finding of that analysis—namely, that the Starlink network, as described in various filings with the Commission, faces significant constraints that prevent SpaceX from satisfying its RDOF obligations. Instead, SpaceX criticizes Viasat for allegedly failing to consider the impact of "technological advances" on SpaceX's ability to "serve increasing customer demand." But under the Commission's RDOF framework, SpaceX cannot rely on vague and unsubstantiated "technological advances" to solve its capacity shortfalls.

Indeed, the Commission has clearly explained that long-form applicants must provide detailed information about how they will meet RDOF performance requirements *using existing, proven technologies*. More specifically, the Commission has emphasized that it would be inappropriate to "test unproven technologies using universal service support." The Commission has also stressed the need to "rely on concrete examples of the technology being used to offer [service meeting applicable RDOF performance requirements]," as failing to do so would make the "risk of default . . . significantly greater . . . ."[3]

The Commission has also explained that while changes in an applicant's system design "may and in many cases will be made throughout the support term," each long-form applicant must demonstrate, *at the long-form application stage*, that it "has a technically feasible solution that will meet the [RDOF] support requirements by the relevant service milestones."[4] In other words, an applicant must demonstrate up front that it has a feasible plan for meeting its RDOF obligations using existing technologies, and provide specific details with respect to that plan so that its feasibility can be validated—even if that plan ultimately changes over time.

The Commission's more granular, specific long-form application requirements reinforce these overarching points. As the Commission explained in the *RDOF Procedures PN*, each long-form applicant (including SpaceX) must demonstrate that it has "a design plan with supportable technologies to meet the relevant [RDOF] public interest obligations in the areas covered by the winning bids" and include "a detailed technology and system design description that explains how the design and technologies chosen will meet the relevant performance requirements . . . ."[5] Applicants also must provide a detailed explanation of how their networks would scale over time and "maintain the performance and quality for the service for the duration of the 10-year support term."[6] And, notably, an applicant using satellite technologies (like SpaceX) must provide detailed information with respect to its specific beam configurations and associated capacity levels, and demonstrate how those configurations and associated capacity levels would enable the applicant to achieve required service milestones.[7]

In short, an applicant is *not* permitted to rely on *future* technological improvements to solve an apparent capacity gap in the *present*. Yet, this is precisely what SpaceX attempts to do.

III. **In any Event, "Technological Advances" Cannot and Will Not Overcome the Starlink Capacity Limitations Identified in Viasat's April 5 Letter**

As noted above, SpaceX's single-paragraph non-response to Viasat's extensive technical analysis essentially reduces to: (i) a vague and entirely unsubstantiated claim that Viasat's analysis is premised on "factual errors" and "incorrect assumptions" of an unspecified nature; and (ii) broad assertions that technological improvements of an unspecified and unproven nature will overcome the significant constraints identified by Viasat.

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3 *See* Rural Digital Opportunity Fund Phase I Auction Scheduled for October 29, 2020; Notice and Filing Requirements and Other Procedures for Auction 904, Public Notice, 35 FCC Rcd 6077, at ¶ 98 (2020) ("RDOF Procedures PN").

4 *Id.* ¶ 305.

5 *Id.* ¶ 301.

6 *Id.* ¶ 308.

7 *Id.* ¶ 311.

A. Viasat's Technical Analysis Was Reasonable and Straightforward, and Relied on Assumptions Favorable to SpaceX (and Perhaps Too Favorable)

As an initial matter, SpaceX provides *no* evidence that Viasat's analysis was in any way premised on "factual errors" or "incorrect assumptions." Tellingly, SpaceX fails to identify even a single instance of either. And SpaceX continues to publicly acknowledge that Starlink is limited by geographic-density constraints. For example, SpaceX's website continues to explicitly state that "Starlink is available to a limited number of users per coverage area,"[8] which is consistent with SpaceX CEO Elon Musk's suggestion that Starlink is engineered to serve "low to medium population density" areas but is "not great for high-density urban" areas.[9] It would be entirely appropriate to compel SpaceX to provide, on the record, a more fulsome explanation of the nature of relevant geographic-density constraints so that the Commission and other stakeholders can fully evaluate how those constraints would impact SpaceX's ability to satisfy its RDOF obligations.

In any event, Viasat's analysis was not particularly complicated, and Viasat was fully transparent with respect to the factual and other assumptions upon which it relied. For example, the first approach reflected in Viasat's technical analysis was an existence proof using simple assumptions that were favorable to SpaceX. Even so, that approach readily established the existence of multiple geographic areas throughout the country where the density of the RDOF locations provisionally awarded to SpaceX exceeds available Starlink capacity given restrictions in SpaceX's NGSO system license (*e.g.,* Nco=1).

The specific methodology used by Viasat under this first approach is described, step-by-step, in Table 1. For each step, the value calculated by Viasat is shown.

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8 *See* https://www.starlink.com/ (last visited May 27, 2021).

9 *See* Michael Kan, *What Is Starlink? SpaceX's Much-Hyped Satellite Internet Service Explained*, PCMAG (Mar. 15, 2021), *at* https://www.pcmag.com/how-to/what-is-starlink-spacex-satellite-internet-service-explained (quoting Elon Musk statement during February 2021 interview with Joe Rogan).

Table 1 – Steps in Viasat's Analysis

Step	Calculation
1. Calculate the maximum Ku-band forward link data rate to a beam area on the Earth's surface that can be delivered by the Starlink system	2 GHz x 2 polarizations x 2.4 bps/Hz = 9.6 Gbps
2. Calculate the minimum required per RDOF location provisioning rate	10 Mbps
3. Calculate the maximum number of RDOF locations that can be supported by the Starlink system in a beam area (divide the result of step 1 by the result of step 2, and then divide by the take rate)	9.6 Gbps / 10 Mbps / 0.7 = 1,371 locations
4. Determine the Starlink Ku-band downlink beam area	22-km diameter circular (-2 dB contour for nadir beam)
5. Determine the number of RDOF locations SpaceX is committed to serve in each beam area	17 areas with an excess of 1,371 locations (and 4,126 locations in one of the 17 areas)
6. If the number determined in step 5 exceeds the number determined in step 3, Starlink cannot fulfill SpaceX's RDOF commitment	31,101 RDOF locations in 9 states that SpaceX has committed to serve

Table 2 below details the basis for the assumptions used by Viasat and explains why they were favorable to SpaceX. As a result of those assumptions, Viasat's analysis actually *understates* the extent of Starlink's capacity issues. For example, Viasat's April 5 analysis relied on location counts provided by the Commission and derived from the CostQuest model—even though the *actual* number of locations in relevant areas is much higher.

Table 2 – Assumptions Used in Viasat's Analysis

Assumptions	**Notes**
Nco = 1	SpaceX has repeatedly represented to the Commission that the maximum number of co-frequency satellites operating in the Ku-band to and from any given point on the Earth is 1.[10]
2,000 MHz of downlink spectrum	SpaceX has stated that the lower 250-MHz Ku-band channel is not usable due to the need to maintain a guardband to protect radio astronomy, a 12.5% reduction in available spectrum.[11]
2 downlink polarizations	SpaceX's blanket UT license specified use of only a single polarization for UT receive, RHC, with LHC being used for UT transmit in the 14-14.5 GHz band.[12] Two downlink polarizations were used in the analysis to provide the best possible case for SpaceX, even though SpaceX has authority to use only one polarization.
2.4 bps/Hz	Based on popular assumption of 600 Mbps per 250 MHz channel. To obtain higher spectrum efficiency, SpaceX would either have to significantly increase downlink pfd (increasing interference potential to both FS and GSO FSS) or significantly increase its UT size. See below for further discussion.
10 Mbps	This reflects the provisioning needed to be able to satisfy the 2 TB per month Above Baseline usage allowance requirement with standard 7% peak busy hour model.
No overhead for waveform or network	Unrealistic assumption favorable to SpaceX. A reasonable, but still generous assumption in SpaceX's favor would have been a factor of 0.8, further increasing SpaceX's shortfall.
70% take rate	Minimum required by the RDOF rules.[13]
22-km circular beam area	This is the diameter of the smallest Starlink Ku-band downlink beam (nadir beam, satellite directly overhead) -2 dB contour.[14] As the satellite moves away from directly above the user, the beam size increases. Both use of the nadir beam and of the -2 dB contour are very favorable to SpaceX.
Use of FCC estimated total locations in each census block	SpaceX is obligated to market to and offer service to all locations in awarded census blocks by milestone 4 whether or not the number is greater than the FCC estimated total. As discussed below, best estimate is that the top 22-km diameter area actually contains 10,331 RDOF locations, 2.5 times the FCC estimate, further increasing SpaceX's capacity shortfall.

10 *See, e.g.,* Letter from SpaceX to FCC, IBFS File No. SAT-MOD-20200417-00037, Att. at 3 (Apr. 2, 2021) (asserting that SpaceX "has always operated its Ku-band downlinks to user terminals consistent with Nco =1 as that parameter is defined by the ITU for its EPFD analysis and will continue to do so in the future.").

11 *See, e.g.,* Letter from SpaceX to FCC, IBFS File No. SAT-MOD-20200417-00037 and RM-11768, Att. at 6 (Dec. 28, 2020).

12 *See* SpaceX Services, Inc., Radio Station Authorization, Call Sign E190066, IBFS File No. SES-LIC-20190211-00151 (granted Mar. 13, 2020).

13 RDOF Procedures PN ¶¶ 77, 303.

14 *See* IBFS File No. SAT-MOD-20200417-00037, "technical_parameters" Attachment, Contours table.

To illustrate this point: Viasat's April 5 analysis identified a 22-km diameter near Chicago, IL, estimated to contain 4,126 locations using the CostQuest model. However, based on the Gadberry NSRF (National Spatial Reference Framework) database, the *actual* number of locations within that 22-km diameter area is 10,331. Those locations are shown in Figure 1, in purple (additional locations outside the 22-km diameter area are shown in black).

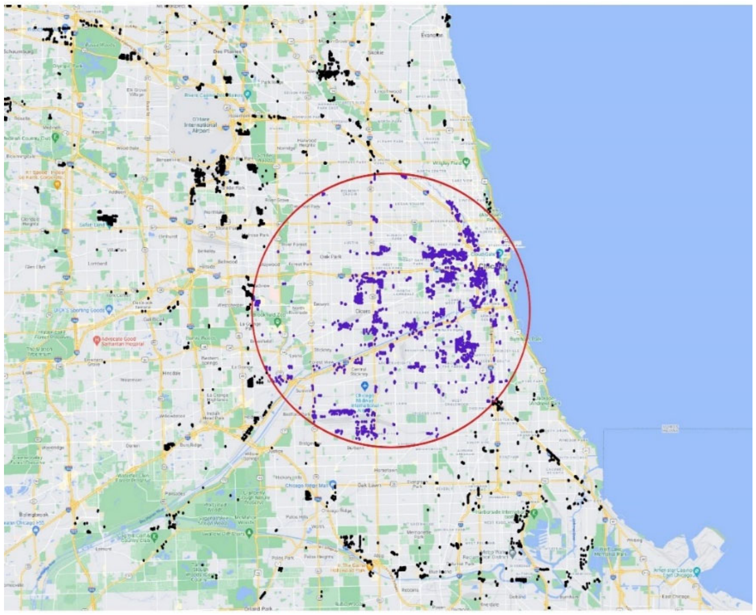

Figure 1 – 22-km Diameter Beam Area (Chicago, IL) with 10,331 Actual Locations (CostQuest Model Estimate was 4,126 Locations)

Similar analysis is provided in Figures 2, 3, and 4 for 22-km diameter beam areas near Fort Myers, FL; Detroit, MI; and Scranton, PA, respectively. In each case, the key takeaway is that while Starlink lacks sufficient capacity to provide required service using the location counts estimated by the CostQuest model, Starlink is even less capable of providing required service to the *actual* location counts as shown using the Gadberry NSRF data.

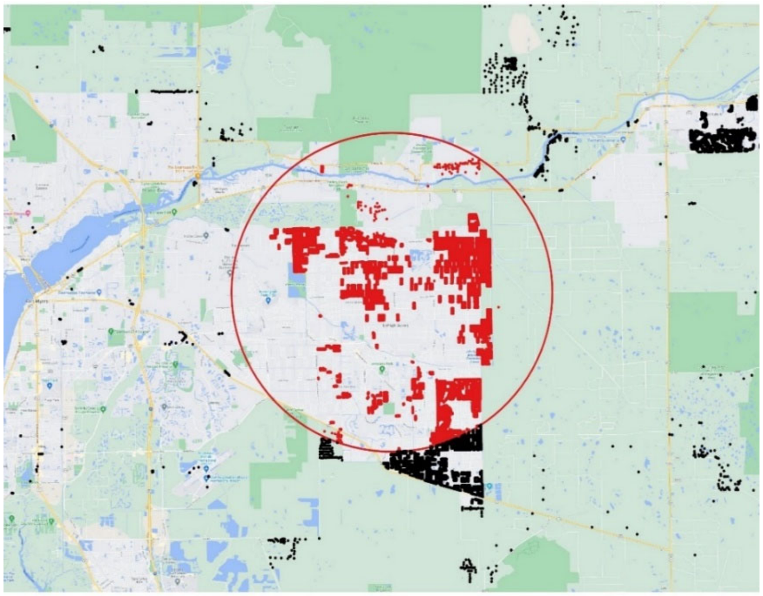

Figure 2 – 22-km Diameter Beam Area (Lehigh Acres near Ft Myers, FL) with 17,879 Actual Locations (CostQuest Model Estimate was 2,331 Locations)

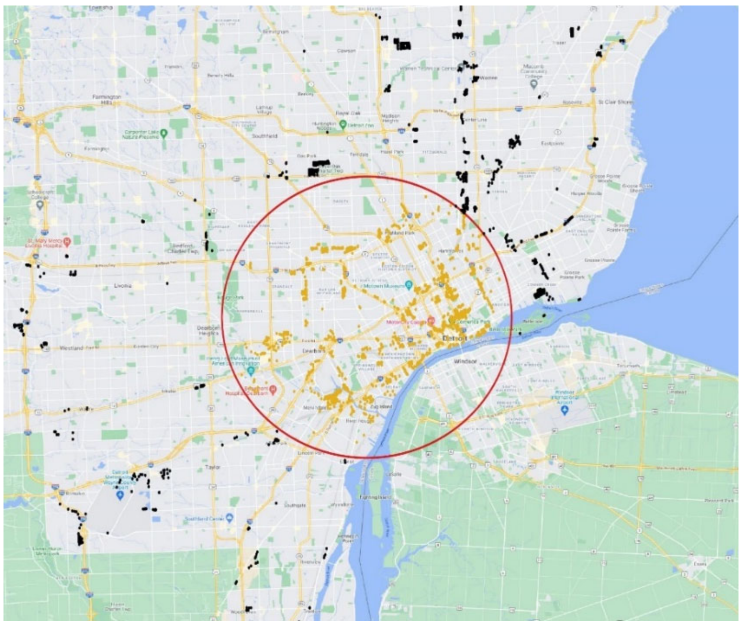

Figure 3 – 22-km Diameter Beam Area (Motown near Detroit MI) with 4,615 Actual Locations (CostQuest Model Estimate was 2,083 Locations)

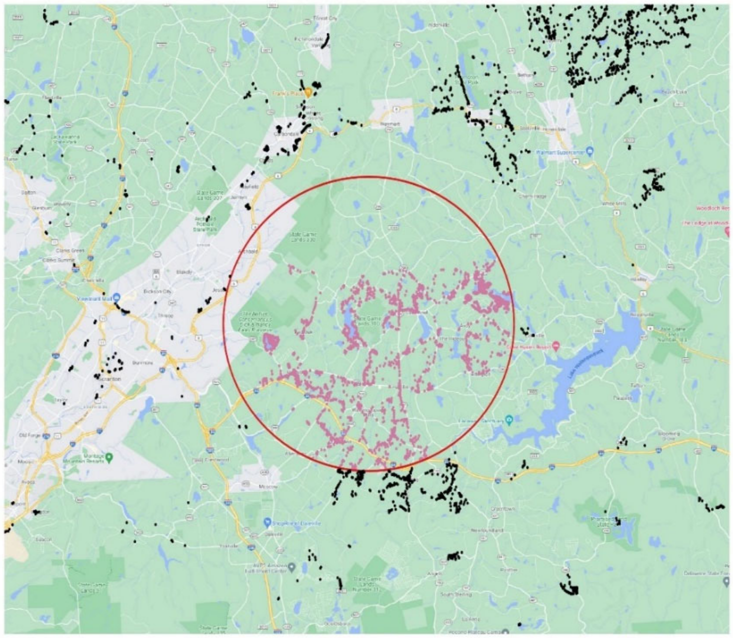

Figure 4 – 22-km Diameter Beam Area (Scranton, PA) with 2,992 Actual Locations (CostQuest Model Estimate was 2,612 Locations)

Notably, under the Commission's RDOF framework, a support recipient must be able to provide service meeting relevant RDOF performance requirements to all locations that are *actually* within supported areas—even if that number is greater than the Commission's initial estimates. Notably, those estimates will be updated, and SpaceX's RDOF service obligation will be tethered to the updated counts.[15] The Gadberry NSRF data strongly suggest that the updated counts will be significantly higher than those originally used by CostQuest—and as Viasat has demonstrated, SpaceX cannot provide service meeting relevant RDOF performance requirements to even the much lower number of locations identified by the initial CostQuest model for the RDOF.

B. SpaceX Is Constrained in Its Ability to Improve Starlink's Network Capacity

As noted above, SpaceX broadly asserts that technological improvements of an unspecified and unproven nature will overcome its current significant capacity constraints. SpaceX further suggests that these improvements would be implemented through newer generations of "customer premises equipment, software, or satellites." None of these options is a feasible path to resolve the significant shortfalls in Starlink capacity that exists for RDOF purposes because of a fundamental disconnect between (i) the maximum theoretical capacity of each Starlink satellite beam given SpaceX's commitment to maintain Nco=1 and (ii) and the geographic density of the specific RDOF locations that SpaceX bid and provisionally won.

15 *See Rural Digital Opportunity Fund*, 35 FCC Rcd 686, at ¶¶ 47-50 (2000).

1. Potential Improvements to Starlink User Terminals

SpaceX could attempt to modify its user terminal design to improve spectral efficiency and increase available capacity. The only viable option for doing so would be to increase G/T (*i.e.,* the ratio of gain to noise temperature). There are two potential ways for achieving this: (i) decrease the noise temperature, T, or (ii) increase the gain, G. For the reasons set forth in the attached Annex, neither of these options is viable.

The first option—reducing noise temperature—would require actual refrigeration to have a significant impact. This is the only way to significantly reduce the thermal noise of an already well-designed low-noise amplifier.

The second option would result in a dramatic increase in terminal size and cost. More specifically, the required antenna diameter would increase by a factor of 3 to 7, depending on assumptions. In other words, it would be necessary to replace the existing 0.48 m diameter Starlink antenna with an antenna that is 1.57 to 3.5 m in diameter.

2. Potential Improvements to Starlink Software

Software improvements cannot increase the amount of spot beam capacity available to the Starlink network, which is limited by available bandwidth and channel capacity, downlink EIRP density, and SpaceX's commitment to maintain Nco=1. Even changes to Starlink modem software allowing operation at the Shannon limit would not solve the problem.

3. Potential Improvements to Starlink Satellites

SpaceX could attempt to modify its satellite design to increase available capacity by increasing EIRP density. However, this is not a viable option, as any attempt to increase EIRP density would result in significant harmful interference to other operators in the terrestrial fixed service, fixed satellite service (GSO and NGSO), and the broadcasting satellite service. As such, it is highly unlikely that the Commission would authorize any such increase.

Furthermore, the "significant interference problems" created for other NGSO systems would have particularly adverse implications for SpaceX under the Commission's *Teledesic* standard. Under that standard, modifications that would cause an NGSO system to exceed the I/N curves defining its authorized interference environment are presumed to be contrary to the public interest as a general matter. Consequently, the Commission would not authorize such a modification (if at all) without moving SpaceX to a later processing round. But this would result in SpaceX losing access to spectrum resources and thus impede—rather than facilitate—SpaceX's ability to overcome technical constraints on its system.

SpaceX could also attempt to secure addition spectrum to use for RDOF. This option is not viable because each RDOF applicant was required to identify the spectrum upon which it would rely, and to have secured necessary rights/access to such spectrum, *prior* to Auction 904. Similarly, under the Commission's RDOF framework long-form applicants must identify the specific spectrum bands that will be used for "last-mile" service, backhaul, and other parts of the network.[16] As such, SpaceX cannot attempt to rely on additional bands at this late date.

IV. Conclusion

The record clearly reflects that the complete 4,408 Starlink constellation cannot satisfy the Commission's RDOF performance requirements for Above Baseline service. Viasat's April 5 letter includes extensive technical analysis that identified significant shortfalls in the Starlink capacity needed to satisfy SpaceX's RDOF obligations. SpaceX has provided *no* meaningful response to that analysis. As such, the Commission cannot, should not, and must not grant SpaceX's long-form application.

Respectfully submitted,

/s/

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Vice President
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Jarrett S. Taubman
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Jonathan McCormack
Mark Montano
Daniel Habif
Joel Rabinovitz

[16] RDOF Procedures PN ¶ 313.

Annex - Increasing Spectral Efficiency

To recap the technical analysis included in Viasat's April 5 letter (attached to that letter as a report entitled "Analysis of the Starlink System's Ability to Satisfy SpaceX's RDOF Commitments"):

- Assuming 600 Mbps per 250 MHz Starlink channel, the maximum forward link capacity to one 22 km diameter spot beam is 9.6 Gbps (8 channels x 2 polarizations x 600 Mbps) for Nco = 1.
- With 10 Mbps per location provisioning and no overheads for waveform or headroom, the maximum number of locations per 22 km spot beam is 1,370.
- If a more realistic derating of 20% overhead due to waveform and headroom and additional derating factors for spectrum sharing were considered, the maximum number of locations per 22 km spot beam would be 870.
- There is a 22 km spot beam area near Chicago, which the initial CostQuest model estimated to contain 4,126 RDOF locations. These locations have been provisionally awarded to SpaceX. Taking account of the 70% RDOF take-rate requirement, Starlink is required to support 2,888 (4,126 x 0.7) locations in this spot beam area. This is impossible given capacity constraints on the Starlink system, which prevent it from serving more than 1,370 locations per area *at most* (ignoring any overhead or derating).
- In total, 17 spot beam areas with an excess of 1,371 locations were identified, which the initial CostQuest model estimated to contain a total of 31,101 RDOF locations in 9 states. SpaceX has committed to serve these locations, but Starlink is incapable of doing so.

For SpaceX to support any of these spot beam areas at the required levels, higher spectral efficiency is required, either by using better modems or by increasing the link margin. For example, in the Chicago spot beam area described above, the spectral efficiency must be increased by a factor of 2.1 (for the ideal 1,370 location assumption), or a factor of 3.3 times (for the more realistic 870 location assumption).

The 600 Mbps data rate per 250 MHz channel represents a spectral efficiency of 2.4 bps/Hz. The required spectral efficiency to satisfy SpaceX's obligation in the Chicago spot beam area described above in the ideal zero overhead case is approximately 5 bps/Hz (2.4 x 2.1), and in the more realistic overhead case is 7.9 bits/Hz (2.4 x 3.3).

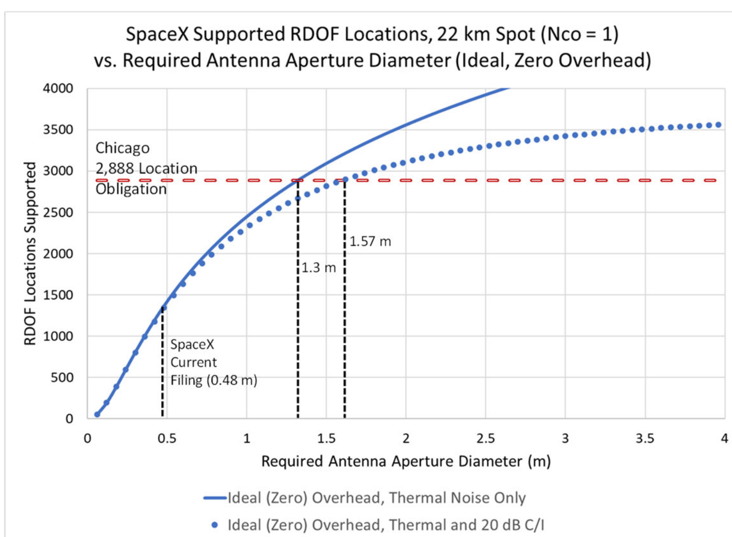
The best possible modem would be one capable of operating at the Shannon limit. With such a modem, improving the spectral efficiency from 2.4 bps/Hz to 5 bps/Hz would require an increase of approximately 9 dB in signal-to-noise-plus-interference-ratio (SINR). Considering thermal noise only and neglecting additional link interference terms such as cross-pol interference, adjacent channel interference, and intermodulation products, achieving a 9 dB improvement in SINR would require some combination of increases in satellite EIRP density and terminal G/T totaling 9 dB.

Even if it did not violate PFD limits or EPFD limits, increasing satellite EIRP density would create additional interference into other co-frequency NGSO systems. That leaves increasing G/T as the only viable option. A 9 dB increase in G/T requires some combination of gain increase and noise temperature reduction totaling 9 dB. The only way to meaningfully decrease noise temperature is with refrigeration. A 9 dB gain increase requires a factor of 8 effective aperture area increase.

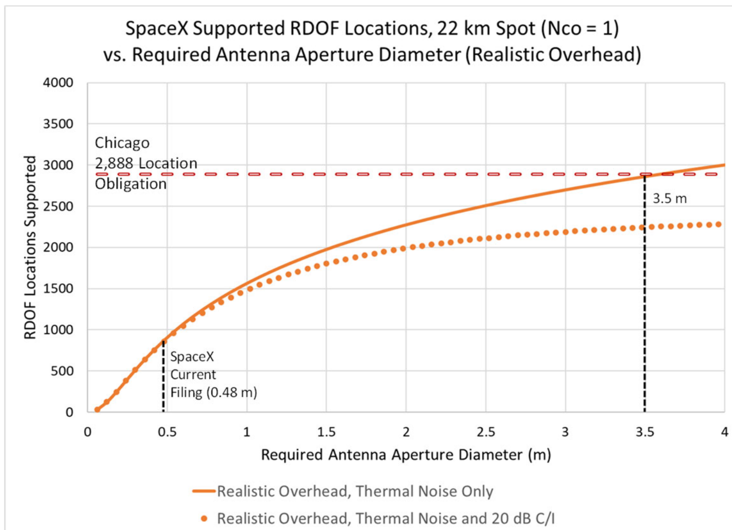
Achieving the 7.9 bits/Hz spectral efficiency required for the more realistic 870 locations per area, even with a Shannon limit modem, would require a 17.5 dB link margin increase. This would require an increase in effective antenna aperture of more than 50 times.

The figures below illustrate the implications on Starlink terminal antenna size should SpaceX attempt to meet its RDOF obligations in the Chicago spot beam area discussed above. The first figure depicts the RDOF locations supportable by SpaceX in a 22 km region (Nco = 1) versus the required antenna aperture diameter, for the ideal zero overhead case. The solid line indicates performance in a thermal noise-only environment, and the dotted line indicates performance assuming a more realistic (though conservative) interference environment from all causes of C/I of 20 dB.

As shown, even in the ideal zero overhead case, the SpaceX antenna diameter must be increased from its current 0.48 m to 1.3 m (thermal only) or to 1.57 m (thermal plus conservative C/I of 20 dB) in order to meet its 2,888 location RDOF Chicago area obligation. Such a change would greatly increase the terminal's weight and power consumption, as well as its size. The associated implications on wind loading, mounting provisions, and installation requirements would result in a fundamentally different terminal than that described in the current SpaceX filings.



The second figure shows the situation with more realistic overhead assumptions—*i.e.,* conservatively allocating 20% overhead for the waveform and headroom, and 20% overhead for spectrum sharing derating (870 locations per 22 km spot). Again, the solid line indicates requirements for a thermal noise-only environment and the dotted line for the realistic but conservative C/I = 20 dB link environment. Even in the unrealistic thermal noise-only case, the aperture size needed to achieve the 2,888 RDOF location obligation exceeds 3.5 m, and in a realistic interference environment, it is impossible, regardless of antenna size. The resulting implications for the SpaceX terminal would amplify the size, weight, and power difficulties mentioned for the zero overhead case above to impractical and nearly absurd levels.



DECLARATION OF MARK A. STURZA

I, Mark A. Sturza, hereby make the following declarations under penalty of perjury:

1. I am President of 3C Systems Company, which has acted as consultant to Viasat, Inc. (“Viasat”) regarding the matters addressed in the foregoing letter and Annex.

2. I prepared the engineering information submitted in the foregoing letter and Annex, or otherwise have reviewed its substance, which is complete and accurate to the best of my knowledge, information and belief.

/s/____________________

Mark A. Sturza
President
3C Systems Company

June 1, 2021